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ABSTRACT

An actuarial model applied to the selection process of a special medical school program at the University of Maryland School of Medicine was tested. The 77 students in the study sample were admitted to the university's Fifth Pathway Program, which is designed for U.S. citizens who completed their medical school training, except for internship and social service years, at a foreign medical school. This program involves a year of supervised clinical training in university affiliate hospitals to prepare students to enter a residency training program. Application data were subjected to multiple regression analysis using post-program clinical performance ratings and test scores as the criterion variables. Preliminary formulae for selection have been developed and several application variables have been combined to predict future performance. The variables of most interest are the Medical College Admission Test scores, which have been shown in previous studies to predict basic science but not clinical performance in medical school. Implications for further research, including a cross-validation study, are discussed. (Author/SW)

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AN ACTUARIAL MODEL FOR SELECTING PARTICIPANTS FOR A SPECIAL MEDICAL EDUCATION PROGRAM

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An Actuarial Model for Selecting Participants for A Special Medical Education Program

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The purpose of this study was to apply an actuarial model to the selection process of a special medical school program. Application data was subjected to multiple regression analysis using post program clinical performance ratings and test scores as the criterion variables. Preliminary formulae for selection have been developed and several application variables combined to predict future performance. The variables of most interest are the Medical College Admission test scores, which have been shown in previous studies to predict basic science but not clinical performance in medical school. Implications for further research, including a cross-validation study, are discussed.

The recent trend in medical school applications has resulted in 2.4 applicants for every U.S. medical school space. The figures for 1978-79 revealed that 25,357 applicants were not accepted into a U.S. medical school. Between four and six thousand U.S. citizens were studying medicine in foreign medical schools, and hoping to practice medicine eventually in the U.S. (Mulvihill & Rosner, 1978).

With such large numbers of applicants every year, the literature in medical education has focused on problems of applicant selection (Murden et al, 1978; Milstein et al, 1980) and studies of the predictive validity of admissions criteria. These studies can be grouped into three categories; those comparing admission criteria and data obtained during or after the first two years of medical school -- the basic science years (Golman & Berry, 1981; Williams et al, 1977), those comparing admission criteria and data obtained during or after the last two years of medical school -- the clinical years (Murden et al, 1978; Willoughby et al, 1979; Dawson-Saunders and Doolen, 1981; Meredith et al, 1982), or those comparing admission criteria and data obtained from both basic science and clinical years (Milstein, 1981). Results of predictive validity studies showed that college GPA is the best predictor of first year medical school performance, and the new MCAT is the best predictor of National Board of Medical Examiners Part I scores (basic science exam) (Golman & Berry, 1981). There is also a relationship between college GPA and old MCAT scores in predicting performance on the National Boards Part I (Williams et al, 1977).

Studies using data obtained from clinical rotations tend to show that selection variables such as MCAT scores, college GPA, and interview ratings did not correlate as well with clinical ratings (Murden et al, 1978) or post graduate performance ratings (Willoughby et al, 1979), but medical school GPA and clinical exam scores do correlate moderately with clinical performance

ratings (Willoughby et al, 1979). A study by Dawson-Saunders & Doolen, (1981) found that the non-science college GPA correlated significantly with clinical ratings of medical students and there was some relationship between the science and qualitative MCAT score and undergraduate science GPA and the medical students' subsequent clinical years performance.

Milstein et al's 1981 study of interview data using both basic science and clinical performance data found no relationship between interview ratings and either of the two performance measures. This study concluded that interviews lend little to the selection process, a conclusion supported by Milstein et al (1980), who found interviewer ratings are influenced by applicant characteristics, interviewer rating biases, and dissimilarities between interviewer and applicant. However, Murden et al (1978) found certain interviewer ratings did correlate with clinical ratings of medical students, and suggested an admissions process based upon both cognitive factors and personal traits.

In response to Murden et al's (1978) suggestion, a study was undertaken by Meredith et al (1982) to study the relationships between objective and subjective admissions selection variables and objective and subjective performance data. As might be expected, they found that to predict objectively measured performance, objective selection variables are most effective, while prediction of subjectively rated performance is improved by the addition of subjective selection variables to the objective measures. The main disadvantage evident from this study is the inordinate amount of time necessary to objectively quantify the subjective narrative ratings of four admissions interviewers per applicant. Thus far, there is a lack of evidence to suggest that this cumbersome procedure is sufficiently more effective than using objective selection variables to warrant the substantial expense in time and funding to quantify interview data.

The literature has led to several recommendations for medical school admissions -- the most popular being random selection from a pool of qualified applicants (Garrison, 1978; Milstein, 1981). Mulvihill & Rosner (1978) reported that of all medical school applicants, approximately half are qualified. The procedure proposed involves medical schools deciding on their admissions criteria, weighting each criterion appropriately, computing a weighted score for each applicant, and randomly selecting applicants from the resulting pool of predetermined contenders. Schmidt and Hunter (1981) discuss the fallacies in the assumption that all that is important is that people to be selected are "qualified," and argue against random selection. They site studies showing that the relationship between ability test scores and employee performance is almost invariably linear, so that selection for optimum performance should not be random, but should begin at the top of the ranking list. Assuming that these findings also may apply to the selection of medical students for optimum performance, the problem is one of determining how the selection variables can be combined to produce the most accurate ranking of applicants.

Lissitz & Malizio (1981) have reviewed the educational and industrial literature and have pointed out several problems evident in this process: interrater reliability of interview data, lack of comparability of GPA's from various schools, and the reiterated conclusion that valid testing does yield results equally accurate as when testing and interview are combined. Dawes (1979) indicated that the literature reveals repeatedly that an actuarial model, one which combines information in a formal manner, consistently is superior to using human judgments to combine data.

While this finding has had mixed receipt by selection committees, there have been at least three such applications of the actuarial model in medical education. Dawson-Saunders & Doolen (1981) used the model to study the relationships among preselection characteristics of applicants with their later

clinical performance, but Williams et al (1977) took the concept further and actually used computer-generated prediction codes from basic science criteria to perform the initial screening of medical school applicants.

Schofield and Garrard (1975) provided support for the actuarial model when they found no difference in performance between students admitted based on a statistical combination of MCAT scores and GPA's and students admitted through the usual process that includes review by committee. Furthermore, the simpler process reportedly has saved time and money both for admissions staff and committee as well as faculty interviewers.

This study involves the application of these findings and models to a unique problem in medical education -- that of selecting students for a "Fifth Pathway Program." This program was set up by the AMA in 1971 for U.S. citizens who completed their medical school training, except internship and social service years, at a foreign medical school. These students generally completed their premedical work at a U.S. college or university but were not accepted into a U.S. medical school. The Fifth Pathway Program involves a year of supervised clinical training in University affiliate hospitals to prepare students to enter a residency training program. Selection of students for the Fifth Pathway Program is a unique process. Data available includes undergraduate GPA, the MCAT score, basic science and clinical performance data, test scores on the National Boards Part I or the Medical Sciences Knowledge Profile, recommendations from preceptors in the U.S. (since many rotations are completed here), the Educational Commission for Foreign Medical Graduates exam (basic science and clinical), and interview ratings. Problems with the data, however, are numerous. Admissions criteria to many foreign medical schools compared to the U.S. schools are considerably more lenient and many of the students would not have been qualified to attend medical school by U.S. standards. Grades assigned by the foreign medical schools tend to be arbitrary and subjective and generally are not trusted by admissions committee members in the U.S.

institutions. The students usually have lower undergraduate GPA's than the U.S. medical students. In some cases they are seen to be "late bloomers," receiving good grades only in their Junior or Senior years of college. Finally, there are many applicants for few positions in the program and time for interviews is restricted.

This study is an attempt to reduce the time and expense necessary to screen a large number of applicants by applying an actuarial model. The objective of the study was to find a formula to aid in selecting students with the highest potential to become a quality physician with the least amount of time and effort expended by the selection committee.

Methodology:

Subjects:

Data for this study was taken from the application files of the Fifth Pathway students who were admitted to the program sponsored by the University of Maryland School of Medicine for 1979-1980 and 1980-1981. This provided a total sample size of 77. All students were assigned an ID number so that their identities could be kept confidential.

Predictor Variables:

Of a possible ten predictor variables available in the students' files for the study, seven were judged to be appropriate for use as possible predictors to Fifth Pathway and residency performance. The ECFMG (Educational Commission for Foreign Medical Graduates) exam score is of primary importance for two reasons. First, the standardized ECFMG exam provides an objective assessment of a student's basic science and clinical knowledge which is essential to the selection of qualified applicants. Second, a passing score of at least 75 is required for participation in the program as well as for licensure in the United States. This cutoff score presents a problem in that the range of scores of qualified students is truncated; however, students

scoring below this minimum criteria have been judged by the Educational Commission to have insufficient knowledge to practice medicine in the United States. Linn (1982) discussed the problems inherent to this type of study relative to range restriction and the basis of selection. The actual basis of selection for Fifth Pathway students is unknown, and the extent of self-selection of applicants is also unknown, therefore corrections to the coefficients cannot be made. It is important to note however, that the ECFMG and other test scores are regarded as important indicators of performance and they are used consistently in the selection of students. Because the range of scores in the selected group may be small, the resulting magnitude of relationships will also be small. However the information obtained is still useful to selection committees as long as results are viewed with a degree of uncertainty.

A second variable judged important for inclusion in this research is the National Boards Part I exam score. This exam also is taken by U.S. medical students as a first step in the licensing process, and objectively assesses knowledge in the basic sciences. Many of the foreign medical students take this exam in hopes of attaining sufficiently high scores to qualify them for transfer to a U.S. medical school. This test score is standardized so that a comparison between the Fifth Pathway applicant and his/her U.S. counterpart is possible. One disadvantage to including this score in the predictor variable list is that not all students take this exam which further reduces the sample size.

The third variable selected for inclusion in this research is actually a set of four scores; the MCAT (Medical College Admissions Test) includes a Verbal, Quantitative, Science, and General Information score. This exam is required of all students applying to U.S. medical schools and thus provides another comparison of the foreign student to the U.S. medical students. The vast majority of Fifth Pathway applicants were rejected from U.S. schools

before enrolling in the foreign schools. Their average MCAT scores are in the average to below average range.

The final variable selected is the undergraduate grade point average (GPA) attained at an accredited U.S. college or university. Again, compared to their U.S. counterparts, the foreign medical students have lower GPA's.

Three variables were considered to be not appropriate for inclusion in this analysis for a variety of reasons: the foreign medical school GPA, letters of recommendations, and interview score. The foreign medical school GPA is considered to be an invalid indication of performance. Quality of foreign medical schools varies greatly in curriculum, quality of instruction, facilities, and admission requirements. Furthermore, little discrimination in the grading process has been observed. Virtually all students receive "good" or "satisfactory" grades, yet knowledge and skills displayed by many students accepted into the Fifth Pathway program has been of poor quality when compared to U.S. standards. Any attempt at quantification of letters of recommendation also was disqualified again due to a lack of variation in the letters. The majority of letters are written by U.S. physicians who supervised the foreign student in a clerkship lasting rarely longer than an eight-week period. This limited exposure of the physician to the student, as well as the general lack of variation in letter content served to discourage inclusion of this variable. Finally, it was decided to exclude interview scores. Presently, each applicant is interviewed by at least three interviewers, who then come to a consensus in classifying the applicant into one of three categories: Plus (+), meaning the student is acceptable for admission to the program; Plus/Minus ($\pm$), meaning the student may be acceptable but the interviewers had reservations; and Minus (-), meaning the student is unacceptable for admission to the program. Again, a lack of variability in the sample occurs because few students with a negative interview score are accepted into the program. During

initial screening, results of analyses indicated that the interview score did not correlate with any of the independent or criterion variables. The main purpose of the research was to come up with a formula to assist in selection screening without the necessity for an interview with every applicant; therefore, interview scales were excluded from the analysis.

Criterion Variables:

Fifth Pathway students are evaluated in several ways; by preceptors on each rotation, by scores on the National Boards Part II administered at the end of the Fifth Pathway year to assess clinical knowledge, and by a rating by the Residency Director at the end of the students' first year of residency. Two of these evaluation variables were chosen as valid measures for comparison by the Fifth Pathway directors. The measures that a consensus of the group felt were most important to be able to predict were an objective measure of clinical knowledge, i.e. the National Boards Part II, and a subjective rating of the Residency Director's level of confidence having the student treat the Director's patients. This rating was on a five point scale; five being, "I would enthusiastically allow this resident to treat one of my patinets," and one being, "I would not allow this resident to treat one of my patients."

Analysis:

Stepwise multiple regression analysis was used to generate prediction formulae for both criterion variables. Because not all students have taken Part I of the National Boards, separate formulae were produced, one for students who had taken the exam (based on an N of 50), one for those who hadn't (based on an N of 72). Altogether, four equations were generated and analysis of variance was used to test each for significance. Data for a cross-validation study was not yet available, but an approximation of expected shrinkage was deemed desirable. The formula to estimate the amount of shrinkage expected of a multiple correlation (Olkin and Pratt as given in Kerlinger and Pedhazur,

1973 is not entirely appropriate when using a selection procedure, because the set of predictor variables will have errors due to the correlation of the variables with the criterion as well as errors due to intercorrelations among the variables. However the authors are not aware of a more appropriate formula for the approximation of shrinkage, and recognizing the increased capitalization on chance, calculated estimates of shrinkage for each multiple correlation using the Olkin and Pratt formula.

RESULTS

The analyses of variance for significance of the four prediction equations is found in Tables 1 - 4. For purposes of clarity, equations will be discussed one at a time.

Prediction equations for students who have taken National Boards Part I:

Criterion Variable: National Boards Part II

Four predictor variables combined to predict the National Boards Part II score. These were National Boards Part I score, General Information MCAT score, ECFMG score, and the Science MCAT score. The analysis resulted in a multiple R of .63 which was significant at the $p < .01$ level, causing rejection of the null hypothesis $Ho: R^2 = 0$, and indicating that the predictor variables account for 40% of the total variance. A significant portion of the variance was accounted for by the Part I predictor variable (see Table 1). The Olkin and Pratt formula to estimate shrinkage led to an R^2 of .30.

Criterion Variable: Confidence of Residency Director

Four predictor variables combined to predict the confidence rating, Verbal MCAT, Science MCAT, General MCAT, and GPA. The analysis resulted in a multiple R of .48 which was significant at the $p < .05$ level, causing rejection of the null hypothesis. The predictor variables account for 23% of the variance and significant portion of the variance was accounted for by the Science MCAT predictor (see Table 2). The Olkin and Pratt formula to estimate shrinkage led to an R^2 of .10.

Prediction equations for students who have not taken National Boards Part I

Criterion Variable: National Boards Part II

Only two predictor variables combined to predict National Boards Part II scores when Part I exam scores were unavailable; ECFMG and General Information MCAT. The analysis resulted in a multiple R of .57 which was significant at the $p < .01$ level, causing rejection of the null hypothesis. The predictor variables account for 32% of the variance and a significant portion of the variance was accounted for by the ECFMG predictor (see Table 3). The Olkin and Pratt formula to estimate shrinkage led to an R^2 of .25.

Criterion Variable: Confidence of Residency Director

Four predictor variables combined to predict the confidence rating when the Part I of the score is unavailable; Science MCAT, Verbal MCAT, General MCAT, and GPA. The analysis resulted in a multiple R of .48, significant at the $p < .01$ level, causing rejection of the null hypothesis. The predictor variables account for 23% of the variance and a significant portion of the variance is accounted for by the Science and Verbal MCAT variables (see Table 4). The Olkin and Pratt formula to estimate shrinkage led to an R^2 of .15.

It should be noted that both equations for predicting confidence rating utilize the same predictor variables and result in identical multiple R values. This is because the Part I score does not enter into either equation, rendering them virtually identical except for minor differences due to fluctuation in the sample size (the additional 20 subjects).

DISCUSSION

A total of three formulas were generated to predict performance on two different criteria; National Board Part II performance and ratings of Residency Director's confidence in the student. The first formula was generated to predict National Board Part II performance from a group of predictor variable

including the National Board Part I score. The rsults demonstrate the value of one standardized test in predicting performance on another standardized test, since Part I was the significant predictor, and, to a lesser extent, so were MCAT scores. The second formula to predict the NB Part II criterion was generated without the NB Part I score as a predictor, yet the same pattern of a standardized score being the most significant predictor occurred when ECFMG emerged as the most valuable predictor in the absence of an NB Part I score. This is important information to a selection committee for this particular program. It comes as no surprise that NB Part I is a predictor of NB Part II. These are sequential exams which assess basic science and clinical knowledge in a similar manner. These exams were, and, in many cases, still are, used by U.S. medical school students as successive hurdles to eventual licensure. When taken by foreign medical students, the exams not only provide a comparison to the U.S. medical student, but also provide some prediction of the students' probability of success on later licensing exams. The ECFMG exam, assessing basic science and clinical performance, is administered only to foreign medical graduates and, therefore, provides no comparative data to U.S. medical graduates and, therefore, provides no comparative data to U.S. medical graduates. The ECFMG, however, does provide some data relative to expected performance on the NB Part II. In regard to the use of test scores, the Fifth Pathway Program is unique in that basic science and clinical exam performance is available at the time of application. From the results of this analysis, it is evident that standardized test scores, specifically NB Part I and the ECFMG are predictors of NB Part II performance. This is especially important because Fifth Pathway students are expected to be able to pass the NB Part II exam and, thus, to prove comparability to their U.S. counterparts at the end of the Fifth Pathway year.

The third formula was generated to predict the Residency Director's rating of confidence in the student. Because the NB Part I score did not enter this

formula as a predictor variable, whether or not a student takes NB Part I becomes irrelevant to predicting the confidence criterion. Therefore, there is no need for separate formulas for those who have and have not taken NB Part I and a single formula for this criterion was identified. The important result for this program lies in the fact that the Verbal and Science MCAT scores were significant predictors of Residency Director's ratings of confidence. Previous studies generally have not shown MCAT scores to be predictive of clinical science performance; however, this analysis suggests Verbal and Science MCAT may be predictive of a more subjective but important parameter of Residency performance.

While the results of this analysis are significant and certainly interesting, the formulas generated leave much variance to be accounted for. While providing significant improvement in predictability, the formulas apparently are missing some important predictor variables. Two variables which may account for further variation are variability among foreign medical schools and clerkship hospitals relative to quality and quantity of training and individual motivation levels of applicants, including commitment to and attitude toward the Fifth Pathway requirements. Addition of measures of these variables to the predictor variable set may improve the formulae substantially, and certainly further research is warranted.

A cross-validation study of these formulae currently is planned; however, the normal shrinkage expected of such a procedure will render the formulae even less effective with the cross-validation group. Initial estimates of the shrinkage support this assumption. Addition of other predictor variables and a corresponding increase in the number of participants in the study may produce results that are more stable and account for a larger percent of the variance.

Before implementation of these formulae could be considered as part of the selection process, another concern will need to be addressed; that of how the two predicted scores are to be utilized. It is possible that because of

the importance of performance on standardized exams, an acceptable cutoff for predicted NB Part II score would be set as the initial screening procedure, followed by the implementation of an acceptable predicted confidence score cutoff to define the set of qualified applicants. Consideration also would have to be given to the determination of whether the selection process would be compensatory or non-compensatory.

Recent and predicted changes in testing procedures are complicating research efforts in this area. For example, foreign medical graduates are no longer allowed to take NB Part I. They are now taking the Medical Sciences Knowledge Profile (MSKP), which is specific for this group of students thus not permitting comparison to U.S. medical students. The MSKP exam does not have a known, validated relationship to the other standardized exams taken by medical students. This change renders formulae with NB Part I as a future predictor already obsolete.

The MCAT scores utilized in this study were from the old MCAT exam. The new MCAT exam, first administered in 1976, consists of six new and different subscales and does not simply replace the old exam. Jones and Thomas-Forgues (1981) found no area of assessment in the new MCAT which corresponds to the verbal skills and general knowledge scales of the old MCAT. This may be a disadvantage since the Verbal MCAT score was a significant predictor of the confidence criterion. The new MCAT, however, does assess student ability to gather, evaluate, and use information which may be of predictive value for these criteria and will require future study.

Even more relevant to this line of research will be the proposed changes in the ECFMG to occur during 1984. The exam will be changed from a one-day to a two-day exam with a higher level of difficulty. Obviously, all of these changes will make further research difficult until the examination situation for foreign medical school graduates stabilizes. In the meantime, however, research into some additional predictor variables may prove valuable, as

as well as studies concerning the relationships among the new and old exams.

Conclusion:

This research was an attempt to apply an acturial model to the selection process of a special medical school program. Results thus far indicate that the model can be effective in predicting both medical science knowledge and clinical skills given the proper predictor variables. Work on this model will continue, including a cross-validation study and research on the inter-relationships between various available predictor variables.

TABLE 1

Analysis of Variance for National Boards Part II Criterion Including the Part I Predictor Variable

N=50

Source	df	SS	MS	F	p	Cumulative Multiple R
Part I	1	94626.18	94626.18	22.82	.01*	.553
General MCAT	1	13794.34	13794.34	3.32	.10	.592
ECFMG	1	8507.19	8507.19	2.05	.25	.615
Science MCAT	1	5941.8	5941.8	1.43	.25	.630
Total Regression	4	122869.51	30717.38	7.41	.01*	
Residual	45	186574.99	4146.11			

TABLE 2

Analysis of Variance for Confidence Criterion Including Part I Predictor Variable

N=50

Source	df	SS	MS	F	p	Cumulative Multiple R
Verbal MCAT	1	1.84	1.84	3.68	.10	.250
Science MCAT	1	2.77	2.77	5.54	.05*	.396
General MCAT	1	1.16	1.16	2.32	.25	.443
GPA	1	1.04	1.04	2.08	.25	.482
Total Regression	4	6.81	1.70	3.41	.05*	
Residual	45	22.56	.50			

TABLE 3

Analysis of Variance for National Boards Part II Criterion Without Part I Predictor Variable

N=72

Source	df	SS	MS	F	p	Cumulative Multiple R
ECFMG	1	166772.62	166772.62	31.91	.01*	.559
General MCAT	1	6083.86	6083.86	1.16	NS	.569
Total Regression	2	172856.48	86428.24	16.54	.01*	
Residual	69	360593.18	5225.99			

TABLE 4

Analysis of Variance for Confidence Criterion Without Part I Predictor Variable

N=72

Source	df	SS	MS	F	p	Cumulative Multiple R
Science MCAT	1	2.27	2.27	5.28	.05*	.247
Verbal MCAT	1	3.92	3.92	9.12	.01*	.407
General MCAT	1	1.39	1.39	3.23	.10	.451
GPA	1	1.09	1.09	2.53	.25	.482
Total Regression	4	8.67	2.17	5.05	.01*	
Residual	67	28.61	.43			

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SELECTION VARIABLES

Variable	Description	Level Compared to U.S. Medical Students	Comments
Undergraduate Grade Point Average (GPA)	Attained at U.S. accredited college or university	below	
Medical College Admissions Test (MCAT)	required of all applicants to U.S. medical schools	----------	replaced in 1976 by new MCAT
Verbal		below	
Quantitative		below	
Science		below	
General Information		below	
Medical school GPA	attained at foreign school	no way to compare with U.S. graduates	no variability in grades, generally not believed to be valid
National Boards, Part I	standardized assessment of basic science knowledge hurdle to licensure in U.S.	below	not taken by all foreign medical students
Educational Commission for Foreign Medical Graduates (ECFMG)	standardized assessment of basic and clinical science knowledge - taken by foreign graduates only	no way to compare	passing score required for entry into program
Letters of Recommendation	written by preceptors with generally limited exposure to student	----------	show little or no variability
Interview Rating	applicants rated + + or - by consensus of three interviewers	----------	little or no variability in selected group, no correlation with criterion